US008606470B2

(12) United States Patent
Nicholson et al.

(10) **Patent No.: US 8,606,470 B2**
(45) **Date of Patent: Dec. 10, 2013**

(54) **LIFT ARM AND IMPLEMENT CONTROL SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 385 days.

(21) Appl. No.: **12/958,998**

(22) Filed: **Dec. 2, 2010**

(65) **Prior Publication Data**

US 2011/0190942 A1 Aug. 4, 2011

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/642,120, filed on Dec. 18, 2009.

(51) **Int. Cl.**
G05D 1/04 (2006.01)

(52) **U.S. Cl.**
USPC **701/50**; 414/685

(58) **Field of Classification Search**
USPC 701/50; 172/2–4; 37/348, 411–416, 37/347; 180/53.4; 414/685, 686, 696–699; 700/169
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,266,909	A	5/1981	Langenfeld	
4,375,344	A	3/1983	Baum et al.	
4,844,685	A	7/1989	Sagaser	
5,188,502	A	2/1993	Tonsor et al.	
5,234,312	A	8/1993	Hirose	
5,924,516	A	7/1999	Sagaser et al.	
6,951,067	B1	10/2005	Dietz et al.	
7,140,830	B2	11/2006	Berger et al.	
7,222,444	B2 *	5/2007	Hendron et al.	37/348
7,530,185	B2	5/2009	Trifunovic	
7,778,757	B2 *	8/2010	Brattberg	701/51
2004/0136821	A1	7/2004	Berger et al.	
2009/0162177	A1	6/2009	Nichols	

FOREIGN PATENT DOCUMENTS

EP	1988220	11/2008
WO	2007054123	5/2007

* cited by examiner

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(57) **ABSTRACT**

A system for a loader stores a signal indicative of a desired inclination of an implement. Upon receiving an operator interface actuation signal, a controller transmits a signal to move the implement to the stored inclination. The controller further transmits a lift arm command signal to move a lift arm towards a lower limit of travel of the lift arm. The lift arm command signal is terminated after the controller receives a signal from a sensor on the lift arm indicating that the lift arm is near its lower limit of travel. After the command signal is terminated, the controller may transmit a second lift arm command signal to further move the lift arm.

20 Claims, 4 Drawing Sheets

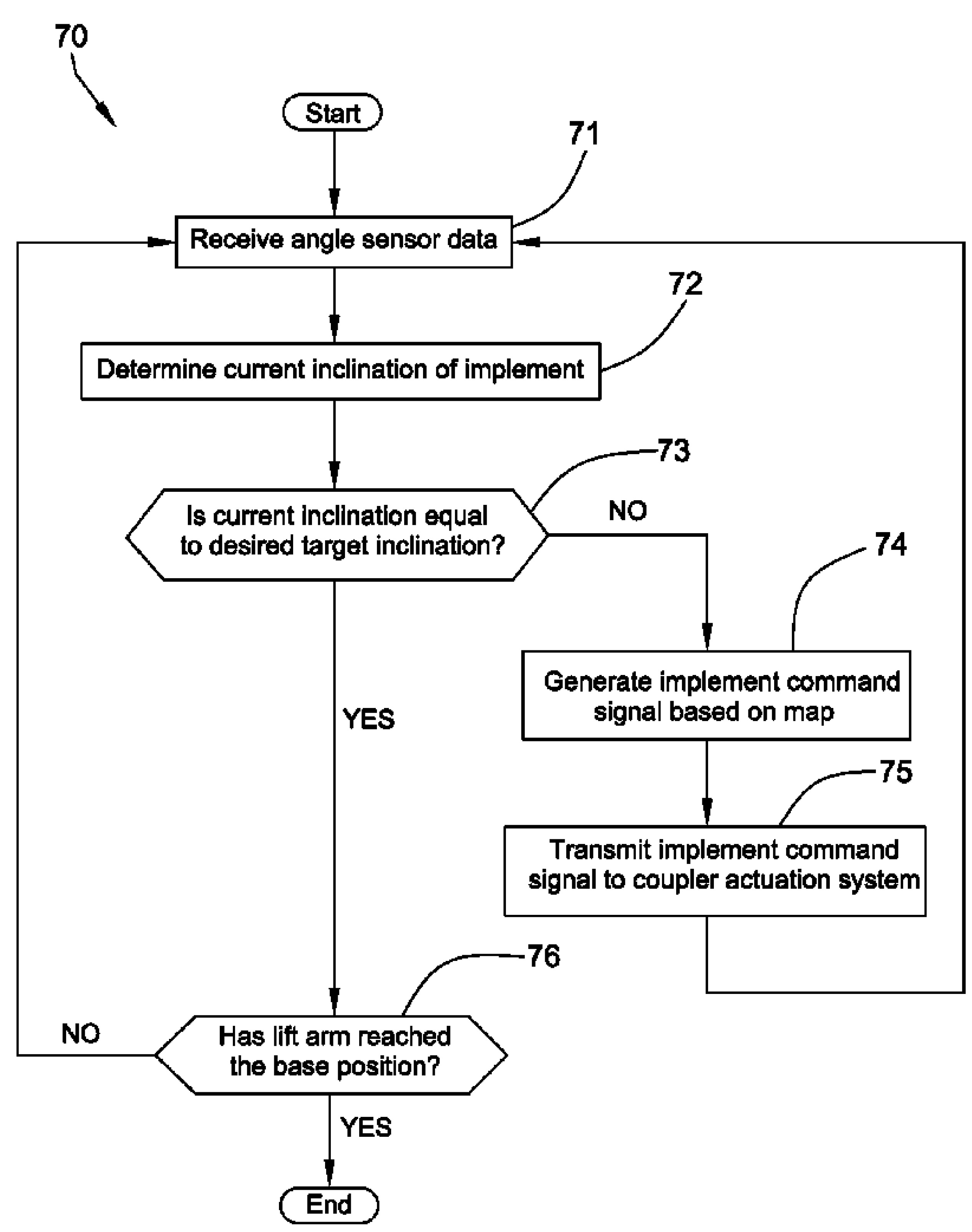


FIG. 1

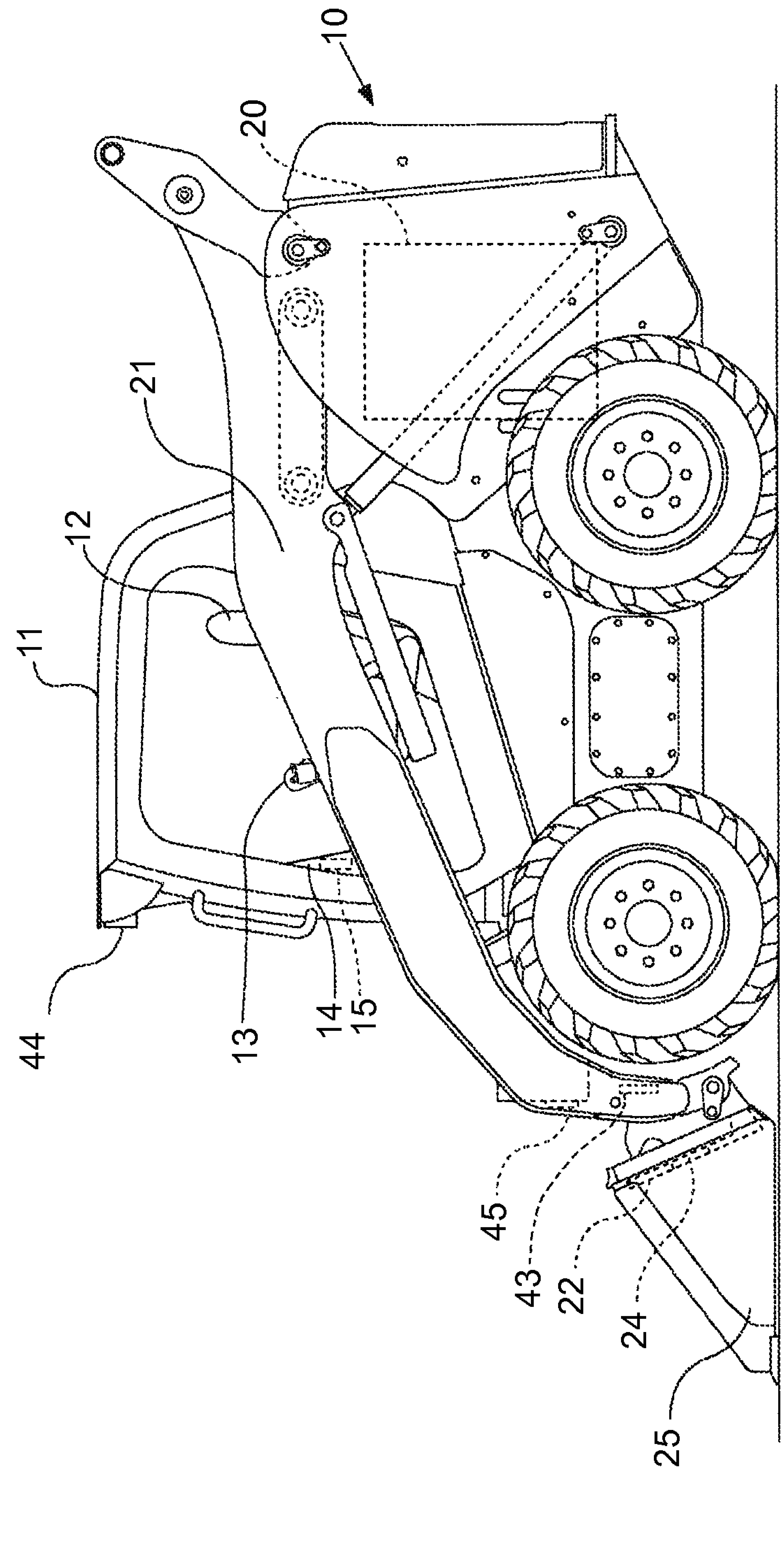


FIG. 2

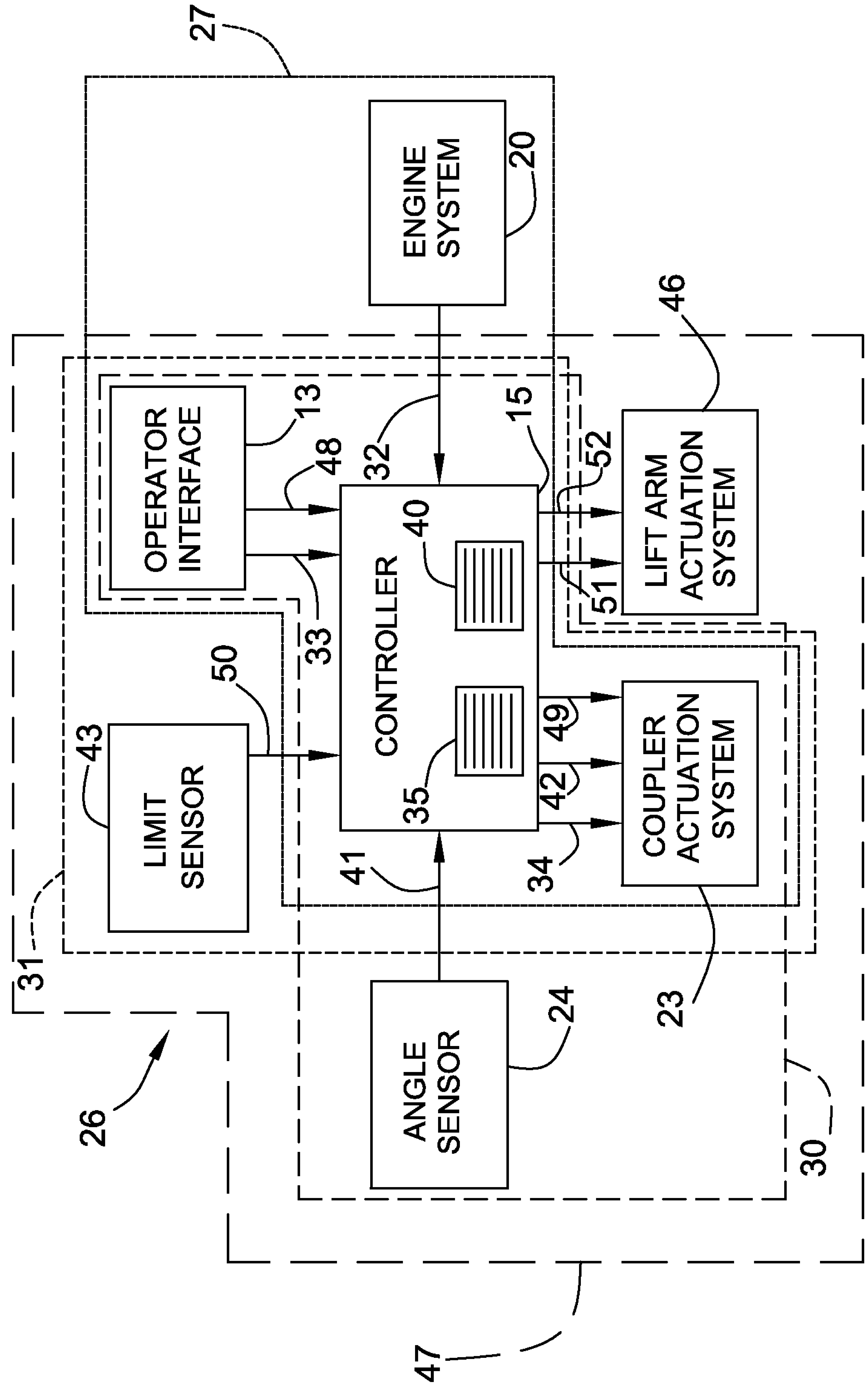

ENGINE SYSTEM
OPERATOR INTERFACE
CONTROLLER
LIFT ARM ACTUATION SYSTEM
LIMIT SENSOR
COUPLER ACTUATION SYSTEM
ANGLE SENSOR

FIG. 3

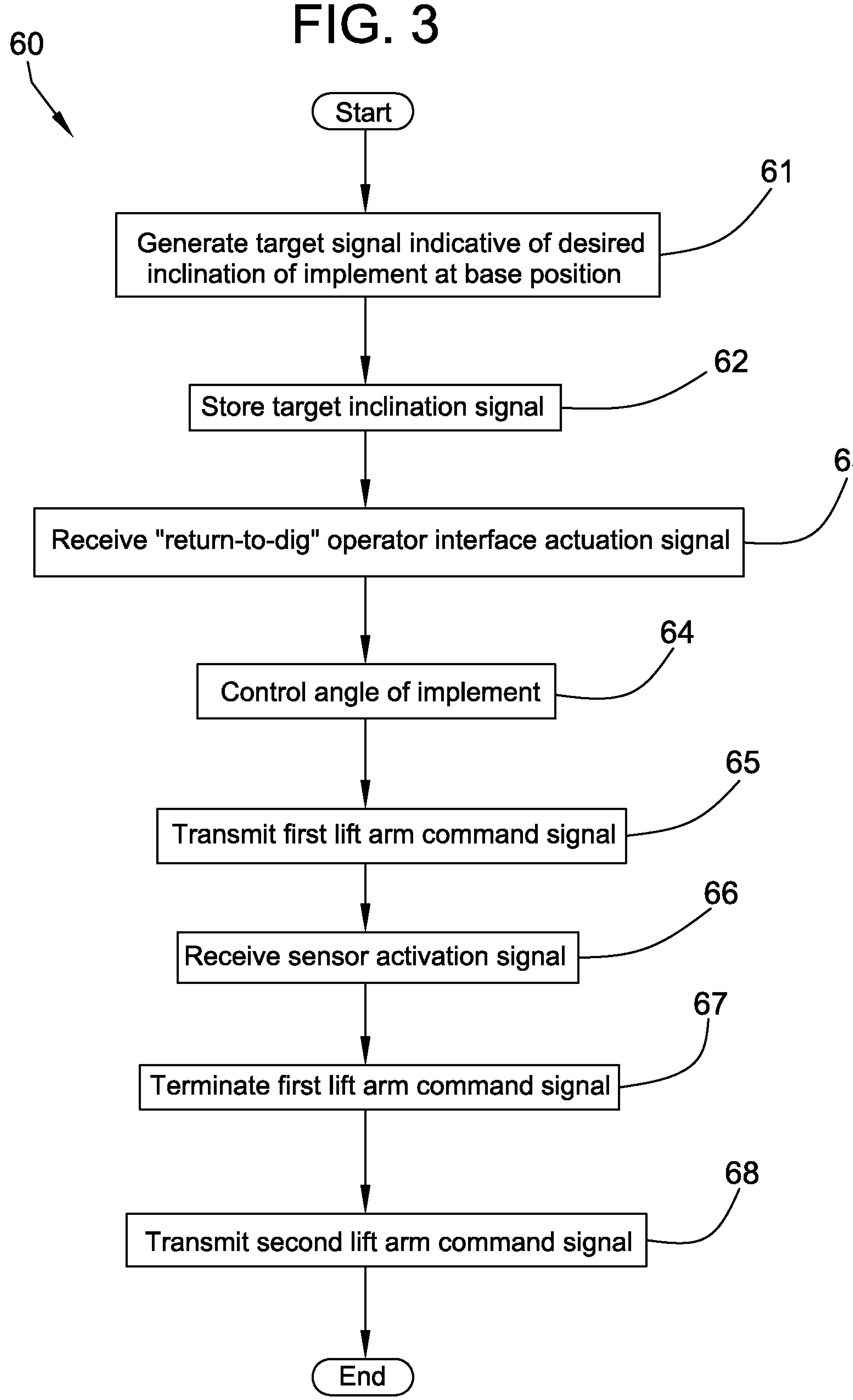
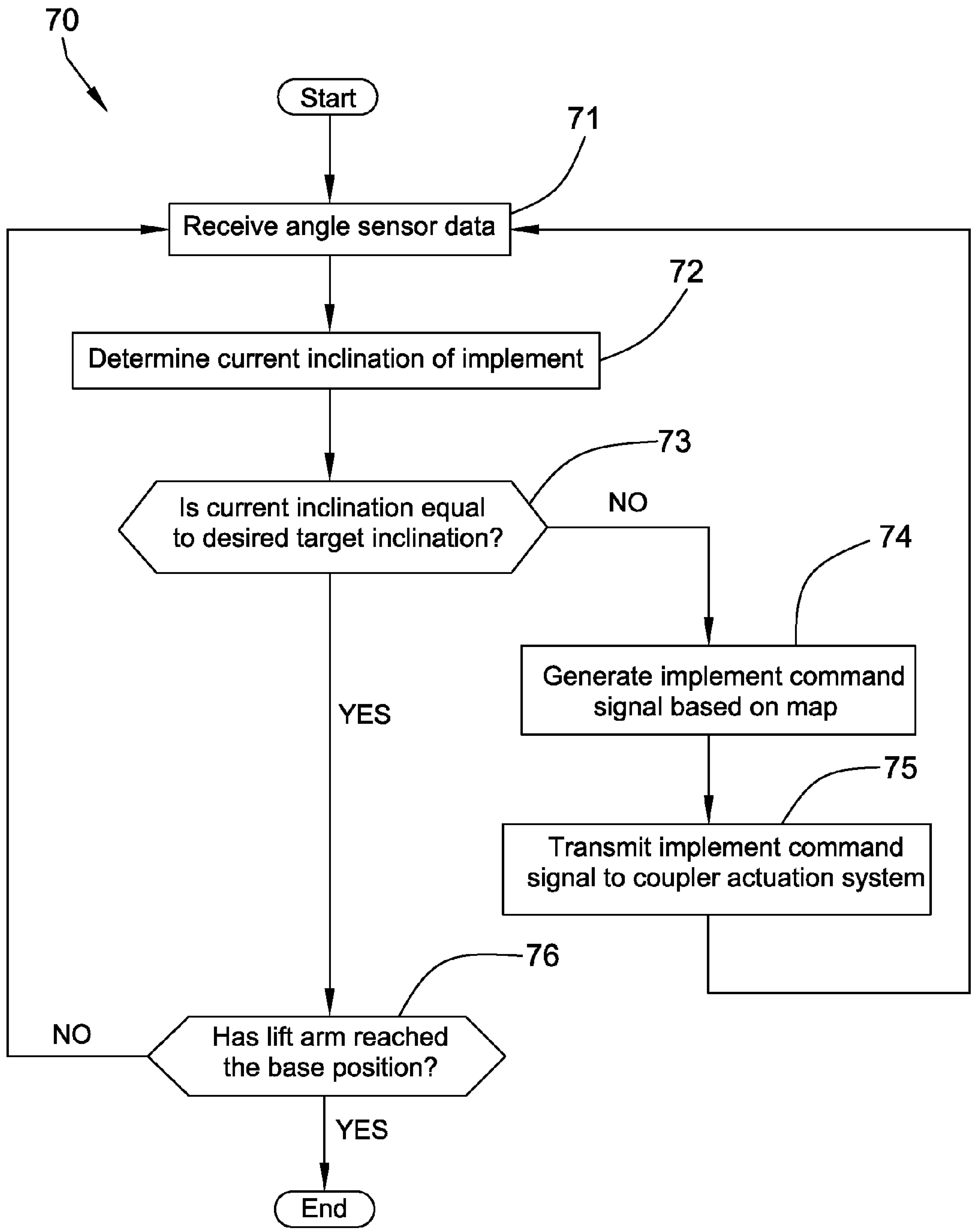

60
Start
Generate target signal indicative of desired inclination of implement at base position
61
Store target inclination signal
62
Receive "return-to-dig" operator interface actuation signal
63
Control angle of implement
64
Transmit first lift arm command signal
65
Receive sensor activation signal
66
Terminate first lift arm command signal
67
Transmit second lift arm command signal
68
End

FIG. 4


70
Start
71
Receive angle sensor data
72
Determine current inclination of implement
73
Is current inclination equal to desired target inclination?
NO
74
Generate implement command signal based on map
75
Transmit implement command signal to coupler actuation system
YES
76
NO
Has lift arm reached the base position?
YES
End

LIFT ARM AND IMPLEMENT CONTROL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is a continuation-in-part of copending U.S. patent application Ser. No. 12/642,120, filed Dec. 18, 2009.

TECHNICAL FIELD

This disclosure relates generally to a system for controlling a lift arm and an implement and, more particularly, to a system for automatically returning a lift arm and an implement to a desired location.

BACKGROUND

Machines with various implements are often used in the materials handling and construction industries. These machines typically include one or more lift arms for moving an implement in order to perform a desired task. The machines are often used for repetitive motions of some type such as lifting a load of material and transporting it to another location. The machine may then be returned to the original location and the implement lowered to the starting position in order to begin another material movement cycle. To achieve maximum production, an operator will often simultaneously steer the machine and adjust the position of the implement. The process can be significantly simplified if the implement were able to return to a preselected position without requiring the attention of the operator.

U.S. Pat. No. 7,140,830 to Berger et al. discloses an electronic control system for skid steer loaders. More specifically, the Berger et al. system provides a complex variety of modes, features, and options for controlling implement position, including an automatic "return-to-dig" mode in which the controller operates to move the implement and boom assembly to a fixed, memorized orientation and position relative to the skid steer loader. However, the Berger et al. system relies largely upon multiple position sensors for information about and to control the implement position which adds cost and complexity to the system.

The foregoing background discussion is intended solely to aid the reader. It is not intended to limit the innovations described herein nor to limit or expand the prior art discussed. Thus the foregoing discussion should not be taken to indicate that any particular element of a prior system is unsuitable for use with the innovations described herein, nor is it intended to indicate any element, including solving the motivating problem, to be essential in implementing the innovations described herein. The implementations and application of the innovations described herein are defined by the appended claims.

SUMMARY

In one aspect, a system for a loader is provided. The system operates to store a signal indicative of a desired inclination of an implement. Upon receiving a signal indicative of actuation of an operator interface, a controller transmits an implement command signal to the system to move the implement to the stored inclination. The controller may further transmit a lift arm command signal to the system to move a lift arm towards a lower limit of travel of the lift arm. After the controller receives a signal indicative of activation of a sensor on the lift arm based upon the sensor being near a sensor trigger on the loader near a lower limit of travel of the lift arm, the controller terminates the lift arm command signal and movement of the lift arm may be terminated. If desired, the controller may transmit a second lift arm command signal to the system to further move the lift arm.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view of a loader in accordance with the disclosure;

FIG. **2** is a schematic diagram of a system for use with the loader of FIG. **1**;

FIG. **3** is a flowchart illustrating a process for controlling automated movement of a lift arm and an implement to a predetermined location; and

FIG. **4** is a flowchart illustrating a process for controlling automated movement of an implement to a predetermined angle of inclination.

DETAILED DESCRIPTION

FIG. **1** illustrates an exemplary loader **10** having a cab **11** housing an operator seat **12**, an operator interface **13**, a control panel **14**, and a controller **15**. The loader **10** further includes an engine system **20**, one or more lift arms **21**, a lift arm actuation system **46**, a coupler **22** mounted on the lift arm **21**, a coupler actuation system **23**, and an angle sensor **24** mounted on the coupler **22**. An implement **25** is attached to the coupler **22**. The operator interface **13**, the control panel **14**, the engine system **20**, lift arm actuation system **46**, the coupler actuation system **23**, and the angle sensor **24** are each configured to communicate with the controller **15**. The loader **10** is provided with sufficient electrical and electronic connectivity (not shown) to enable such communication. Though the illustrated loader **10** is a skid steer loader, the loader may be any other type of loader.

The controller **15** may be a single microprocessor or a plurality of microprocessors and could also include additional microchips and components for random access memory, storage, and other functions as necessary to enable the functionalities described herein. The lift arm actuation system **46** is an electro-hydraulic actuation system linking the controller **15** and the lift arm **21** and controlling movement of lift arm **21**. The coupler actuation system **23** is an electro-hydraulic actuation system linking the controller **15** and the coupler **22** and controlling movement of coupler **22** and thus also controlling movement of implement **25**. The angle sensor **24** of the disclosed embodiment may be an inclinometer that provides an angle of the coupler relative to a ground reference. Other types of angle sensors for measuring the inclination of implement **25** may also be used. Although the illustrated implement **25** is a bucket, the implement may be any other type of implement attachable to the coupler **22**.

Referring to FIG. **2**, a system **26** of loader **10** is depicted for controlling movement of lift arm **21** and an angle of the implement **25**. The system **26** includes an open loop subsystem **27**, a closed loop subsystem **30**, a limit subsystem **31**, and a "return-to-dig" subsystem **47**. The open loop subsystem **27** includes the operator interface **13**, the controller **15**, the engine system **20**, and the coupler actuation system **23**. Specifically, in the open loop subsystem **27**, the controller **15** is configured to receive a signal **32** indicative of the speed of the engine in the engine system **20** and a signal **33** indicative of an actuation of the operator interface **13**. The operator interface actuation signal **33** is indicative of a command from an operator for the lift arm **21** to move at a speed associated with the degree of operator interface actuation. For instance, the operator interface **13** may be a joystick and commanded lift arm movement speed may vary directly with joystick displacement. Based at least upon the engine speed signal **32** and the operator interface actuation signal **33**, the controller **15** calculates a first angle correction signal, also referred to herein as an open loop correction signal **34**. The controller **15** then transmits the open loop correction signal **34** to the coupler actuation system **23** to move the coupler **22** which also results in the movement of the implement **25** attached to the coupler **22**.

The controller **15** calculates the open loop correction signal **34** by multiplying an initial correction calculation by an engine speed factor. The initial correction calculation is associated with the commanded lift arm movement speed, whereas the engine speed factor is associated with the engine speed indicated by the engine speed signal **32**. These associations may be specified in maps, lookup tables, or similar data structures programmed into the controller **15**. Specifically, upon receiving the operator interface actuation signal **33** and discerning a commanded lift arm movement speed from the operator interface actuation signal **33**, the controller **15** accesses a first map **35** that associates lift arm movement speeds with initial correction calculations and utilizes the first map **35** to determine the initial correction calculation associated with the lift arm movement speed indicated by the operator interface actuation signal **33**. In addition, upon receiving the operator interface actuation signal **33**, the controller **15** determines the engine speed indicated by the engine speed signal **32**, accesses a second map **40** that associates engine speeds with engine speed factors, and utilizes the second map **40** to determine the engine speed factor associated with the engine speed indicated by the engine speed signal **32**. Then, as mentioned above, the controller **15** multiplies the initial correction calculation by the engine speed factor to arrive at the open loop correction signal **34** to be transmitted to the coupler actuation system **23**.

The closed loop subsystem **30** includes the operator interface **13**, the controller **15**, the coupler actuation system **23**, and the angle sensor **24**. Specifically, in the closed loop subsystem **30**, the controller **15** receives a coupler angle signal **41** from the angle sensor **24** mounted on the coupler **22** and calculates a second angle correction signal, also referred to herein as a closed loop correction signal **42**, based at least upon the coupler angle signal **41**. More specifically, when the operator interface actuation signal **33** received by the controller **15** includes a command to start lift arm movement or to change the direction of lift arm movement from up to down or vice versa, the controller **15** stores the coupler angle most recently indicated by the coupler angle signal **41** as a target angle. The controller **15** then monitors the coupler angle signal **41** for deviations from the target angle. Then the controller **15** calculates the difference between the stored target angle and the actual angle continually indicated by the coupler angle signal **41** and, based upon the calculated difference between the angles, transmits the closed loop correction signal **42** to the coupler actuation system **23** such that the coupler **22** is moved to the extent necessary for the actual angle indicated by the coupler angle signal **41** to match the target angle.

The limit subsystem **31** includes the operator interface **13**, the controller **15**, the coupler actuation system **23**, a sensor such as a limit sensor **43** (FIG. **1**), and upper and lower sensor triggers **44**, **45**. The sensor may be any type of presence or proximity sensor, while the sensor triggers **44**, **45** may be metal strips or any other elements configured to trigger the limit sensor **43**. If desired, the sensor could be a mechanical switch triggered as it moves past trigger structures. The limit sensor **43** is mounted on the lift arm **21** of the loader **10** and the sensor triggers **44**, **45** are mounted on the loader **10** such that the limit sensor **43** detects the presence of the sensor triggers **44**, **45** as the lift arm approaches its upper and lower limits of the travel, respectively.

In one embodiment, the sensor triggers **44**, **45** may be positioned approximately 10-12 inches before reaching the physical upper and lower limits of travel of lift arm **21**. More specifically, referring to FIG. **1**, lift arm **21** is depicted at its lower limit of travel position. As depicted, limit sensor **43** is not aligned with the lower sensor trigger **45** when lift arm **21** is positioned at its lower limit of travel, but rather positioned slightly below or past the lower sensor trigger. This configuration permits the end of the lift arm **21** to continue to travel approximately 10-12 inches after limit sensor **43** passes lower sensor trigger **45**. Similarly, lift arm **21** may continue to travel approximately 10-12 inches above or past upper sensor trigger **44** after limit sensor **43** passes the upper sensor trigger. The exact amount of travel past the sensor triggers may be adjusted as desired by appropriately configuring the controller **15**.

When the limit sensor **43** detects the presence of one of the sensor triggers **44**, **45**, the limit sensor **43** transmits a binary signal or limit signal **50** to the controller **15**. The controller **15** is configured to receive the limit signal **50** and, upon receipt of the limit signal, to discontinue transmitting the open and closed loop correction signals **34**, **42** to the coupler actuation system **23**. Automatic movement of the coupler **22** by the system **26** is thus discontinued adjacent the limits of travel of the lift arm **21**, thereby helping to prevent overcorrection of the angle of the coupler **22**, and by extension, overcorrection of the angle of the implement **25**.

The controller **15** is also configured to calculate a position of the lift arm **21** based at least upon the limit signal **50**. The controller **15** calculates the position of the lift arm **21** by referring to the operator interface actuation signal **33** to determine which direction the operator interface actuation signal **33** most recently commanded the lift arm **21** to move. When the controller **15** receives a limit signal **50**, if the operator interface actuation signal **33** indicates that the lift arm **21** was most recently commanded to move up, the controller **15** concludes that the limit sensor **43** has sensed the presence of the upper sensor trigger **44** and, by extension, that the lift arm **21** has reached a position near the upper limit of lift arm travel. Similarly, if the operator interface actuation signal indicates that the lift arm **21** was most recently commanded to move down, the controller **15** concludes that the limit sensor **43** has sensed the presence of the lower sensor trigger **45** and, by extension, that the lift arm **21** has reached a position near the lower limit of lift arm travel.

The "return-to-dig" subsystem **47** includes the operator interface **13**, the controller **15**, the coupler actuation system **23**, the angle sensor **24**, the limit sensor **43** and the lift arm actuation system **46**. System **26** utilizes a "return-to-dig" mode in which the controller **15** operates to return the lift arm **21** to a starting or base position adjacent its lower limit of travel of lift arm **21** and return implement **25** to a stored or memorized orientation. In one example, an operator may perform some type of repetitive work operation with lift arm **21** and implement **25** such as digging material with a bucket. The operator may move the lift arm **21** and implement **25** to a carrying position while moving loader **10** to another location at which the material is removed from the implement (e.g., dumped from a bucket). As the operator returns the loader **10** to the original location to begin the work cycle again, it may be desirable for the operator to simultaneously and automatically move the lift arm **21** and work implement **25** to the base position in order to maximize production. This base position is often referred to as a "return-to-dig" position even though it need not be a position or orientation used for digging. At the base or "return-to-dig" position, lift arm **21** is positioned near its lower limit of travel and implement **25** is positioned at an orientation specified by the operator. Accordingly, the base position includes two components—one specifying the position of the lift arm **21** and one specifying the orientation of implement **25**. The desired position of lift arm **21** relative to the lower limit of travel may be set by a configuration within the controller **15** while the desired orientation of the implement may be set by the operator.

FIG. **3** is a flowchart **60** depicting the "return-to-dig" process. After the implement **25** is positioned at a desired angular orientation, the operator actuates a component of operator interface **13** such as a switch in order to generate at stage **61** a target signal indicative of the desired inclination of the implement at the base position. Controller **15** then stores the target inclination signal at stage **62**.

Once the target inclination signal indicative of the desired inclination of coupler **22**, and thus implement **25**, has been stored within controller **15**, the operator may move lift arm **21**, implement **25** and loader **10** as desired in order to perform the operator's desired tasks. The operator may return lift arm **21** and implement **25** to the base position at any time by sending a "return-to-dig" operator interface actuation signal **48** to controller **15** based upon actuation of operator interface **13** such as by pressing a "return-to-dig" switch at stage **63**. Upon receiving such a "return-to-dig" operator interface actuation signal **48**, controller **15** begins to control the angle of implement **25** at stage **64** by monitoring the coupler angle signal **41** for deviations from the target inclination signal. The controller **15** then calculates the difference between the stored target inclination angle and the actual angle continually indicated by coupler angle signal **41** and, based upon the calculated difference between angles, transmits an implement command signal **49** to coupler actuation system **23** such that coupler **22** is moved to the extent necessary for the actual angle indicated by the coupler angle signal **41** to match the target inclination signal.

In addition, at stage **65**, controller **15** transmits a first lift arm command signal **51** to the lift arm actuation system **46** which moves lift arm **21** downward. Since the loader **10** only includes a limit sensor **43** on lift arm **21** and sensor triggers **44** and **45** on loader **10**, the exact position of lift arm **21** relative to loader **10** is often not known by controller **15**. In other words, controller **15** is able to determine when lift arm **21** is near or above upper sensor trigger **44** but when lift arm **21** is positioned such that limit sensor **43** is between upper sensor trigger **44** and lower sensor trigger **45**, controller **15** cannot determine the exact distance of lift arm **21** from the lower sensor trigger **45** or the lower limit of travel due to the simplified sensor system of loader **10**. Accordingly, controller **15** provides the first lift arm command signal **51** to lift arm actuation system **46** to propel or move lift arm **21** downward at a predetermined rate until limit sensor **43** on lift arm **21** reaches lower sensor trigger **45**.

Moving limit sensor **43** near or adjacent sensor trigger **45** activates the limit sensor **43** at stage **66** changing its status from either off to on or on to off depending on the type of limit switch used and such status change is monitored by controller **15** at stage **66**. Based on the status change of limit sensor **43**, controller **15** recognizes that lift arm **21** is positioned with limit sensor **43** near lower sensor trigger **45**. Controller **15** then terminates the first lift arm command signal **51** at stage **67** in order to terminate the downward movement of lift arm **21**. If desired, controller **15** may, at stage **68**, transmit a second lift arm command signal **52** to the lift arm actuation system **46** in order to continue the movement of the lift arm downward from a position in which limit sensor **43** is generally aligned with lower sensor trigger **45** to another position closer to its lower limit of travel. This additional downward movement directed by second lift arm command signal **52** may be slower than the downward movement directed by the first lift arm command signal **51**. In other words, controller **15** may be configured so that once limit sensor **43** reaches lower sensor trigger **45**, it either stops lift arm **21** or supplies a second lift arm command signal **52** to lift arm actuation system **46** to move lift arm **21** further downward towards its lower limit of travel. It may be possible to configure controller **15** such that the second lift arm command signal moves the lift arm **21** upwards away from the lower limit of travel, if desired.

Since, in one embodiment, loader **10** does not include sensors to determine when lift arm **21** has reached its lower limit of travel, controller **15** is configured to estimate the speed and duration of downward movement necessary for lift arm **21** to reach its lower limit of travel and generates the second lift arm command signal **52** based on that estimate. The controller then sends the second lift arm command signal **52** to the lift arm actuation system **46** at stage **68**. If desired, controller **15** may be configured such that the second lift arm command signal positions lift arm **21** at a position other than close to the lower limit of travel by changing the calculation of the second lift arm command signal.

Referring to FIG. **4**, flowchart **70** depicts the process by which controller **15** controls the angle of inclination of implement **25**. Since lift arm **21** is rotated downward during the "return-to-dig" process and the angle of inclination in the depicted embodiment is measured by an inclinometer that measures the angle of coupler **22** relative to an earth reference, the angle of implement **25** relative to the earth reference will constantly change as lift arm **21** moves. Accordingly, controller **15** is configured to monitor the coupler angle signal **41** from angle sensor **24** and interact with coupler actuation system **23** in order to position implement **25** in the desired inclination once lift arm **21** reaches its lower limit of travel. More specifically, once the operator sends the "return-to-dig" operator interface actuation signal **48** to actuator **15** at stage **63** of FIG. **3**, the controller **15** receives data from the angle sensor **24** at stage **71** (FIG. **4**) and uses the angle sensor data to determine the current inclination of implement **25** at stage **72**. The current inclination is compared to the stored target inclination at a stage **73**. If the current inclination is not equal to the desired inclination, controller **15** generates an implement command signal **49** in order to move coupler **22**, and thus implement **25**, towards the target inclination signal. The implement command signal **49** may be based upon a data map contained within the controller **15** that may be a function of the difference between the current angle of inclination and the stored target inclination angle. Once the implement command signal **49** is generated, controller **15** transmits the implement command signal at stage **75** to the coupler actuation system **23** in order to move the coupler **22** and implement **25** in the desired direction. After transmitting the implement command signal **49** at stage **75**, controller **15** continues to receive angle sensor data at stage **71** in order to properly position coupler **22** and implement **25**.

If the current inclination as determined by controller **15** at stage **72** is equal to the desired target inclination at stage **73**, controller **15** determines whether lift arm **21** has reached its base position at stage **76**. Once lift arm **21** has reached its base position, it will no longer be rotating or moving downward and thus no longer affecting the inclination of implement **25**. As such, if lift arm **21** and implement **25** are at their base positions, the automated control of the lift arm and implement may be terminated. If the lift arm **21** has not reached its base position, further movement of lift arm **21** will change the angle of inclination of implement **25** and thus automated adjustment of the angle of inclination of coupler **22** and implement **25** is continued at stage **71** until the current angle of inclination equals the desired target angle of inclination and the lift arm **21** has reached its base position. An operator may cancel the "return-to-dig" process once it has begun by operating the operator interface **13** or another operator control in a predetermined manner.

If desired, system **26** may be used to provide the functionality of automatically returning implement **25** to a desired target angle of inclination without also moving lift arm **21** to its base position. In such an operation, an operator generates a target signal indicative of the desired angle of inclination of the implement in a manner similar to that of stage **61** of FIG. **3** but without moving the implement to the base position. For example, the operator may move the implement to the desired inclination and move an operator interface in a predetermined manner. The movement of the operator interface may cause the target inclination signal to be stored within controller **15** in a manner similar to stage **62**. Once the operator provides an appropriate operator interface actuation signal in a manner similar to stage **63**, system **26** operates in a manner similar to that set forth in flowchart **70** of FIG. **4** except that monitoring of the position of arm **21** at stage **76** is omitted.

INDUSTRIAL APPLICABILITY

The industrial applicability of the system described herein will be readily appreciated from the foregoing discussion. The present disclosure is applicable to many machines and many tasks accomplished by machines. One exemplary machine for which the system is suited is a wheeled loader. However, the system may be applicable to any type of loader and any type of machine that would benefit from automated movement of a lift arm and an associated implement to a pre-selected position such as a "return-to-dig" position.

The disclosed system operates to stores a signal indicative of a desired inclination of an implement. During the course of operating the loader, an operator may want to move the lift arm and implement to a base position defined by the lift arm being positioned near its lower limit of travel and the implement being positioned at its stored inclination. Upon the operator actuating a designated operator interface, the controller of the system generates and transmits an implement command signal to an electro-hydraulic system to move the implement to the stored inclination. The controller further generates and transmits a lift arm command signal to the electro-hydraulic system to move a lift arm towards a lower limit of travel of the lift arm. After the controller receives a signal indicating that a sensor on the lift arm is adjacent a sensor trigger on the loader near the lower limit of travel of the lift arm, the controller terminates the lift arm command signal and movement of the lift arm may be terminated. If desired, the controller may transmit a second lift arm command signal to the electro-hydraulic system to further move the lift arm.

In addition, system may operate in a similar manner but without moving the lift arm to a position near its lower limit of travel. This functionality may be desirable when loading the implement at a first inclination and unloading it at a second orientation without moving the lift arm **21**.

It will be appreciated that the foregoing description provides examples of the disclosed system and technique. However, it is contemplated that other implementations of the disclosure may differ in detail from the foregoing examples. All references to the disclosure or examples thereof are intended to reference the particular example being discussed at that point and are not intended to imply any limitation as to the scope of the disclosure more generally. All language of distinction and disparagement with respect to certain features is intended to indicate a lack of preference for those features, but not to exclude such from the scope of the disclosure entirely unless otherwise indicated.

Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context.

Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A system for automated movement of a lift arm and an implement of a loader from a remote position to a base position near a lower limit of travel of the lift arm, the system comprising:
- a sensor mounted on one location of the lift arm and the loader;
- a sensor trigger mounted on another location of the lift arm and the loader; and
- a controller configured to:
  - store a signal indicative of a desired inclination of the implement, the desired inclination being a component of the base position;
  - receive a signal indicative of actuation of an operator interface on the loader, the operator interface actuation signal indicating a desired movement of the lift arm and the implement to the base position; and
  - responsive to receiving the operator interface actuation signal:
  - transmit an implement command signal to an electro-hydraulic system to move the implement to the desired inclination;
  - transmit a lift arm command signal to the electro-hydraulic system to move the lift arm towards the lower limit of travel of the lift arm;
  - receive a signal indicative of activation of the sensor mounted on one location of the lift arm and the loader based upon movement of the sensor near the sensor trigger mounted on another location of the lift arm and the loader at a position near the lower limit of travel of the lift arm; and
  - terminate the lift arm command signal based upon receipt of the sensor activation signal.

2. The system of claim **1**, wherein the controller is further configured to transmit a second lift arm command signal to the electro-hydraulic system to control the movement of the lift arm near the lower limit of travel of the lift arm after termination of the lift arm command signal.

3. The system of claim **2**, wherein the controller is further configured such that transmission of the implement command signal occurs generally simultaneously with the transmission of at least one of the lift arm command signal and the second lift arm command signal.

4. The system of claim **2**, wherein the controller is further configured such that the second lift arm command signal includes both a magnitude and a duration for directing movement of the lift arm near the lower limit of travel of the lift arm.

5. The system of claim **1**, wherein the controller is further configured such that the automated movement of the lift arm and implement is cancelled upon receipt of a second, predetermined operator interface actuation signal after receipt of the operator interface actuation signal.

6. The system of claim **1**, wherein the controller is further configured to store as the desired inclination signal a single signal generated by an inclination sensor that measures inclination of the implement relative to an earth reference.

7. A loader, comprising:
- a movable lift arm;
- an implement movably coupled to the lift arm;
- an operator interface;
- an inclination sensor configured to sense inclination of the implement;
- a sensor mounted on one location of the lift arm and the loader;
- at least one sensor trigger for activating the sensor, the sensor trigger defining a trigger position near a lower limit of travel of the lift arm, the sensor trigger being mounted on another location of the lift arm and the loader; and
- a controller configured to:
  - store a signal from the inclination sensor indicative of a desired inclination of the implement;
  - receive a signal indicative of actuation of the operator interface, the operator interface actuation signal indicating a desired movement of the lift arm and the implement to a base position, the base position including the lift arm being positioned near the lower limit of travel and the implement being positioned at the desired inclination; and
  - responsive to receiving the operator interface actuation signal:
  - transmit an implement command signal to an electro-hydraulic system to move the implement to the desired inclination;
  - transmit a lift arm command signal to the electro-hydraulic system to move the lift arm towards the lower limit of travel of the lift arm;
  - receive a signal indicative of activation of the sensor based upon movement of the sensor near the sensor trigger at the trigger position near the lower limit of travel of the lift arm; and
  - terminate the lift arm command signal based upon receipt of the sensor activation signal.

8. The loader of claim **7**, wherein the controller is further configured to transmit a second lift arm command signal to the electro-hydraulic system to control the movement of the lift arm near the lower limit of travel of the lift arm after termination of the lift arm command signal.

9. The loader of claim **8**, wherein the controller is further configured such that transmission of the implement command signal occurs generally simultaneously with the transmission of at least one of the lift arm command signal and the second lift arm command signal.

10. The loader of claim **8**, wherein the controller is further configured such that the second lift arm command signal includes both a magnitude and a duration for directing movement of the lift arm near the lower limit of travel of the lift arm.

11. The loader of claim **7**, wherein movement of both of the lift arm and the implement is cancelled upon receipt of a second, predetermined operator interface actuation signal after receipt of the operator interface actuation signal.

12. The loader of claim **7**, wherein the sensor is a switch providing binary signals to the controller.

13. The loader of claim **12**, wherein the switch is a proximity sensor.

14. The loader of claim **7**, wherein the controller is further configured such that the lift arm command signal includes a magnitude for directing movement of the lift arm for a sufficient time so that the sensor mounted on the one location of the lift arm and the loader moves near the sensor trigger.

15. The loader of claim **7**, wherein the inclination sensor is mounted on a coupler coupling the lift arm and the implement.

16. A controller-implemented method for automated movement of a lift arm and an implement of a loader to a base position adjacent a lower limit of travel of the lift arm, the method comprising:
- storing a signal within a controller indicative of a desired inclination of the implement, the desired inclination being a component of the base position;
- receiving a signal at the controller indicative of actuation of an operator interface on the loader, the operator interface actuation signal indicating a desired movement of the lift arm and implement to the base position; and
- upon receiving the operator interface actuation signal:
- transmitting an implement command signal from the controller to an electro-hydraulic system to move the implement to the desired inclination;
- transmitting a lift arm command signal from the controller to the electro-hydraulic system to move the lift arm downward towards the lower limit of travel of the lift arm;
- receiving a signal at the controller indicative of activation of a sensor mounted on one location of the lift arm and the loader based upon movement of the sensor near a sensor trigger mounted on another location of the lift arm and the loader at a position near the lower limit of travel of the lift arm; and
- terminating the lift arm command signal based upon receipt of the sensor activation signal at the controller.

17. The method of claim **16**, further including the step of transmitting a second lift arm command signal from the controller to the electro-hydraulic system to control the movement of the lift arm near the lower limit of travel of the lift arm after termination of the lift arm command signal.

18. The method of claim **17**, wherein the step of transmitting the implement command signal occurs generally simultaneously with transmitting at least one of the lift arm command signal and the second lift arm command signal.

19. The method of claim **17**, wherein the step of transmitting the second lift arm command signal includes transmitting both a magnitude and a duration for directing movement of the lift arm near the lower limit of travel of the lift arm.

20. The method of claim **16**, further including the step of cancelling the movement of the lift arm and implement upon receipt of a second, predetermined operator interface actuation signal at the controller after receipt of the operator interface actuation signal.

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